

**INTERSTELLAR DUST MODELS
CONSISTENT WITH EXTINCTION, EMISSION,
AND ABUNDANCE CONSTRAINTS**

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ABSTRACT

We present new interstellar dust models which have been derived by simultaneously fitting the far ultraviolet to near infrared extinction, the diffuse infrared emission, and, unlike previous models, the elemental abundances in dust for the diffuse interstellar medium. We found that dust models consisting of a mixture of spherical graphite and silicate grains, polycyclic aromatic hydrocarbon (PAH) molecules, in addition to porous composite particles containing silicate, organic refractory, and water ice, provide an improved fit to the UV-to-infrared extinction and infrared emission measurements, while consuming the amounts of elements well within the uncertainties of adopted interstellar abundances, including B star abundances. These models are a significant improvement over the recent Li & Draine (2001, *ApJ*, 554, 778) model which requires an excessive amount of silicon to be locked up in dust: 48 ppm (atoms per million of H atoms), considerably more than the solar abundance of 34 ppm or the B star abundance of 19 ppm.

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Despite the considerable efforts of many researchers over past decades, we are still missing a thorough and reliable model of interstellar dust that would consistently explain a variety of available observed data. For example, even the composition of interstellar dust is still a matter of debate.

In the work presented here, we explore possible dust models that simultaneously comply with the three major observational constraints (see Figure 1): the average interstellar extinction, the thermal infrared emission from the diffuse ISM, and the interstellar abundance constraints. Other important constraints such as the interstellar polarization and X-ray halos are left for future research.

From a mathematical point of view, the problem of deriving the grain size distributions and composition reduces to a Fredholm integral equation of the first kind. To solve this typical ill-posed inverse problem, we implemented a special tool, the method of regularization (Tikhonov et al. 1995; Zubko 1997). Compared to other approaches, the method of regularization requires the minimum amount of information: the data to be fit and their uncertainty, without a need for default or template solutions.

Recently, Li & Draine (2001) proposed a dust model that consists of the polycyclic aromatic hydrocarbons (PAHs), graphite and silicate grains. Their model is consistent with the observed extinction and emission data, but requires too much silicon, magnesium, and iron to be in the dust: 48 ppm (atoms per million H atoms), significantly more than the maximum available solar abundance of 34 ppm.

Here we show that the Li & Draine model can be optimized by choosing different, more general size distributions (BARE models), thus producing good fits to the observational constraints without violating the abundance constraints. A more complex dust model (COMP) consisting of PAHs, bare graphite and silicate grains, and porous composite particles made up from silicates, organic refractory, and water ice, provides a somewhat improved fit to the observed constraints, including the interstellar abundances. This kind of dust model looks more realistic than the model in the light of the current view on the dust evolution and available IR data.

Our favored model is a COMP model with the solar abundances from Holweger (2001) assumed as the interstellar medium abundances (see Figure 2). It has minimum discrepancies in fitting the extinction and IR emission; it also looks better in explaining the observed infrared extinction and scattering properties: albedo and asymmetry parameter. Note that we also find equally good COMP models using B star and F and G stars abundance constraints.

One of the main results of the work is that no unique dust model can be chosen. In part, this can be explained by the paucity of observational constraints compared to the number of free model parameters.

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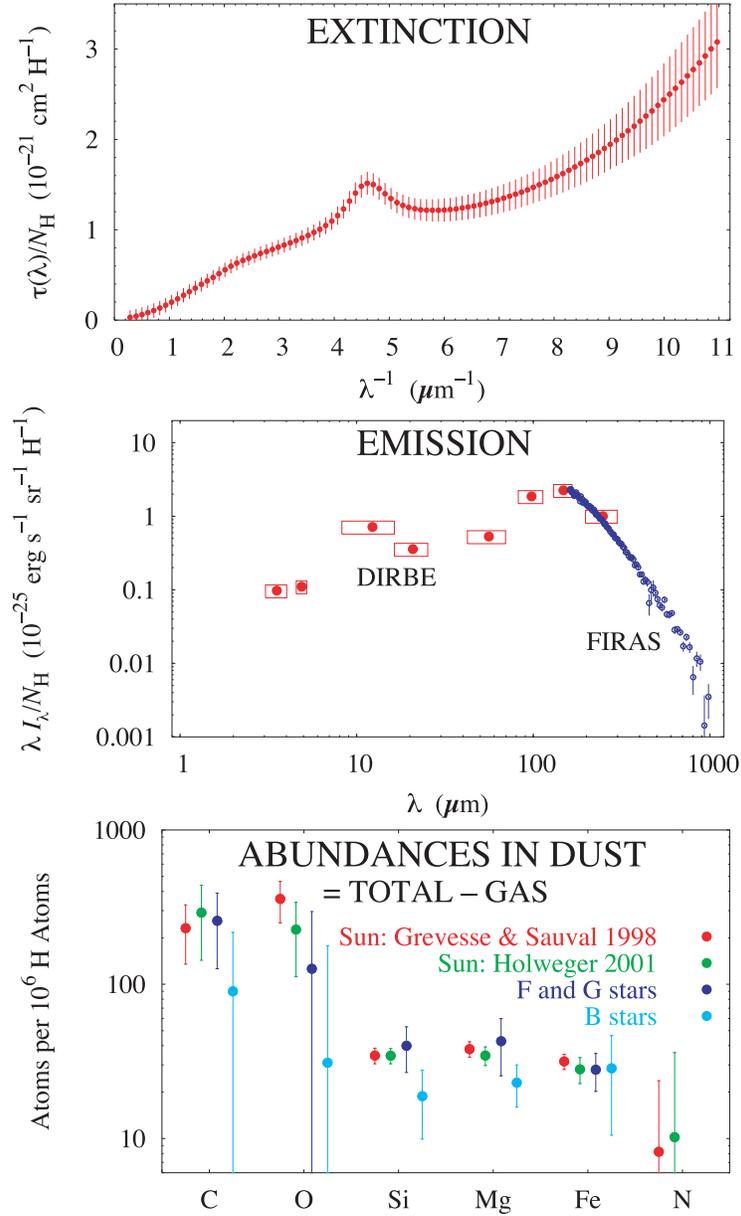


Fig. 1.— The mean Galactic extinction curve (Fitzpatrick 1999) (upper panel), infrared emission from high Galactic latitudes (Arendt et al. 1998; Dwek et al. 1997) (middle panel), and abundances in dust (lower panel).

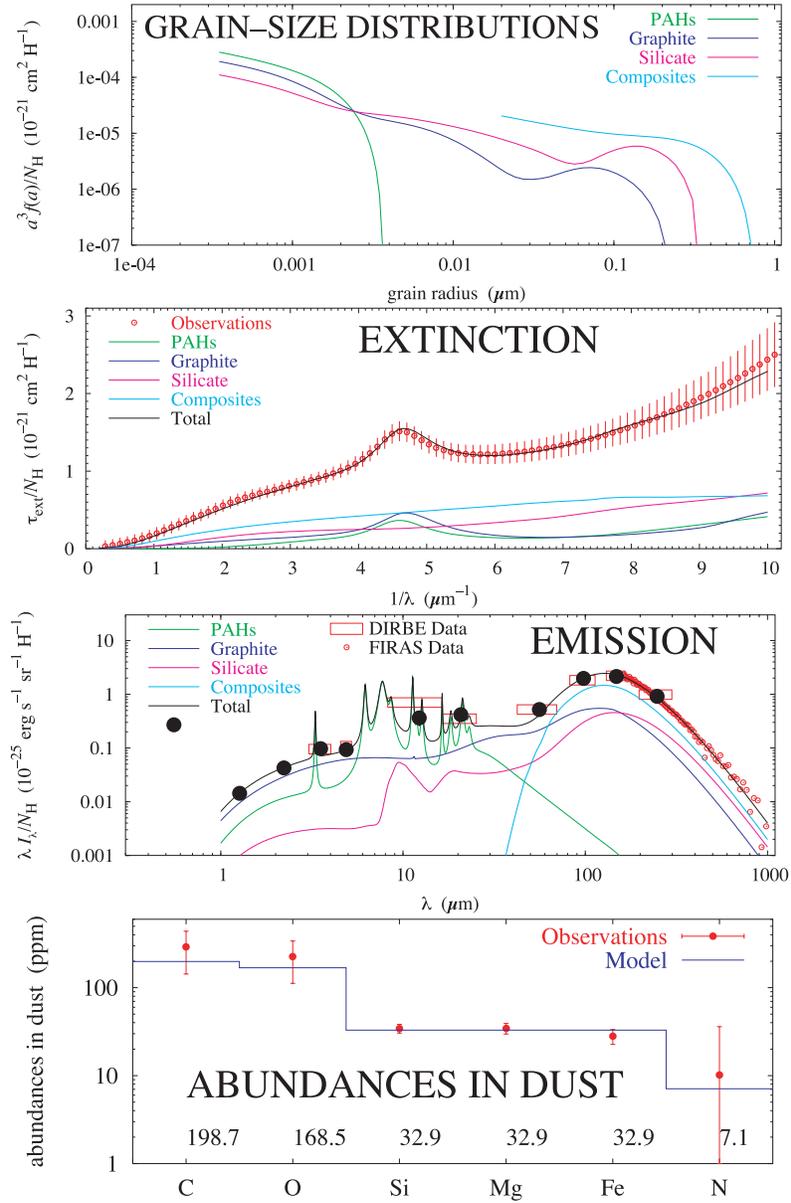


Fig. 2.— Our preferred dust model, COMP-S2: size distributions, extinction curve, emission spectrum, and elemental requirements. For abundances, solid line and numbers along the x -axis show model results